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### (54) Catheter reinforcing braids

Geflechte zur Verstärkung von Kathetern

Entrelacs renforçant des cathéters

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**Description**

[0001] The present invention relates to a catheter according to the preamble of the main claim.

[0002] Several types of catheters are utilized for intravascular treatment. Examples of intravascular catheters include 5 guide catheters, angioplasty catheters, stent delivery devices, angiographic catheters, neuro catheters, and the like.

[0003] Guiding catheters are commonly used during coronary angioplasty procedures to aid in delivering a balloon catheter or other interventional medical devices to a treatment site in a coronary vessel. In a routine coronary angioplasty procedure, a guiding catheter is introduced into a peripheral artery and advanced over a guidewire through the aorta until the distal end of the guiding catheter is engaged with the appropriate coronary ostium. Next a balloon dilatation catheter is introduced over the guidewire and through the guiding catheter. The guidewire is advanced past the' 10 distal end of the guiding catheter within the lumen of the diseased vessel and manipulated across the region of the stenosis. The balloon dilatation catheter is then advanced past the distal end of the guiding catheter over the guidewire until the balloon is positioned across the stenotic lesion. After the balloon is inflated to dilate the blood vessel in the region of the stenotic lesion, the guidewire, balloon dilatation catheter and guiding catheter are withdrawn.

[0004] Guiding catheters typically have preformed bends formed along their distal portion to facilitate placement of 15 the distal end of the guiding catheter into the ostium of a particular coronary artery of a patient. In order to function efficiently, guiding catheters should have a relatively stiff main body portion and soft distal tip. The stiff main body portion gives the guiding catheter sufficient "pushability" and "torqueability" to allow the guiding catheter to be inserted percutaneously into a peripheral artery, moved and rotated in the vasculature to position the distal end of the catheter 20 at the desired site adjacent to a particular coronary artery. However, the distal portion should have sufficient flexibility so that it can track over a guidewire and be maneuvered through a tortuous path to the treatment site. In addition, a soft distal tip at the very distal end of the catheter should be used to minimize the risk of causing trauma to a blood vessel while the guiding catheter is being moved through the vasculature to the proper position. Such a soft tip is described in U.S. Patent No. 4,531,943. In addition, the inner surface of the guiding catheter should be lubricious to 25 facilitate movement of guidewires, balloon catheters and other interventional medical devices therethrough.

[0005] Angiographic catheters can be used in evaluating the progress of coronary artery disease in patients. Angiography procedures are used to view the patency of selected blood vessels. In carrying out this procedure, a diagnostic catheter having a desired distal end curvature configuration may be advanced over a guide wire through the vascular system of the patient until the distal end of the catheter is steered into the particular coronary artery to be examined.

[0006] A non-limiting example of an angioplasty catheter is found in U.S. Patent No. 4,646,742. A non-limiting example of a stent deployment device is found in U.S. Patent No. 5,201,757.

[0007] A catheter according to the preamble of the main claim is shown in WO 93/08986 which discloses a flexible reinforced tubing of the type having a wire braided reinforcing layer disposed adjacent one or more coating layers of 35 plastic material. The individual wire filaments of the reinforcement layer are plastic encapsulated to promote better adhesion between the wire braided reinforcement layer and plastic coating layers. In one embodiment, the base coat layer is omitted and the wires are coated with highly lubricous material, preferably a polyhalogenated polyolefin such as PTFE or KEL-F plastic. Radially inward facing surface portions of the PTFE coated wires are left exposed to the lumen to increase lubricity. The unexposed surface portions of the PTFE coated wires are selectively etched to promote better adhesion to the top coat layer extruded thereover.

[0008] EP 0 520 692 A1 discloses a soft tip guiding catheter foratraumatic insertion into delicate, tortuous coronary vessels and introduction of an angioplasty balloon catheter therethrough. The guiding catheter includes a main tubular portion and a soft tubular tip with respective, matching external and internal tapers for increasing the contact area of the thermal bond. The outer and inner diameters of the main portion are uniform and match the respective outer and inner diameters of the soft tip for providing a uniform outer catheter surface and a continuous, uniform catheter passageway surface. The tapers further provide for a gradual change in durometer between the main portion and soft tip. The main portion preferably includes an inner layer of lubricous material, an outer layer of a polyether block amide, and a reinforcing braid positioned therebetween. The layers of the main portion provide a thin catheter wall with pushability, torqueability, and kink resistance. The composite durometer of the main portion is I harder than the durometer 45 of the soft tip, which comprises a combination of polyether block amide material and tungsten for increasing the radiopacity thereof.

[0009] US-A-5,180,376 shows an introducer sheath includes an extremely thin, flat wire metal coil that is surrounded only on its exterior surface with a plastic tube or coating. The flat wire coil optimizes the resistance of the sheath to buckling while minimizing the wall thickness of the sheath. The plastic covering being only on the outside of the metal coil optimizes the thinness of the introducer sheath wall while still providing a smooth outer surface for easy percutaneous insertion into an artery or other vessel of a living body. The higher density of the metal coil as compared to the plastic tubes of existing introducer sheaths, maximizes the radiopacity of the sheath for this thin-walled design. An alternative embodiment consists of two flat wire metal coils, one wound over the other, with a plastic covering the outer 55 surface of the outer metal coil.

- [0010] US-A-4,898,591 shows inner and outer layers of a braided body portion of an intravascular catheter as well as a soft tip portion are formed from different proportioned blends of nylon and copolymer of ester linked polyethylene and polyamide to produce optimum mechanical properties in the catheter. One or more surfaces of the catheter are coated with a hydrogel containing a copolymer of polyurethane and polyvinylpyrrolidone to provide improved lubricity and antithrombogenicity. In that the path taken by intravascular catheters is sometimes tortuous, it is important that an intravascular catheter can be steered by torquing its proximal hub and that the torque be transmitted to the distal end in a smooth, controllable fashion. Moreover, the catheter should have sufficient strength in the longitudinal direction so as not to kink or fold as it is advanced through the vascular system. It should also possess a lubricious core lumen to facilitate passage of a guidewire or possibly another catheter or device therethrough.
- [0011] It is also a desirable feature of certain intravascular catheters that it possess a relatively large lumen to allow fluids, such as radiopaque contrast fluid to be injected therethrough and out the distal end so that the area of the vascular system under investigation can be viewed fluoroscopically.
- [0012] It is also a desirable feature of certain intravascular catheters that it possess radiopaque and/or kink resistance qualities.
- [0013] The desirable properties of a catheter having a relatively small O.D. and a relatively large I.D. dictates a relatively thin wall. To maintain the desired torqueability and pushability characteristics of a thin wall catheter calls for considerable ingenuity in the formulation of the materials employed and the constructional techniques utilized.
- [0014] It is an object of the invention to provide a catheter which has a relatively large lumen while possessing radiopaque and kink resistance qualities.
- [0015] This object is achieved according to the invention by the catheter as defined in claim 1.
- [0016] Advantageous embodiments of the invention are the subject of the sub-claims.
- [0017] The catheter of the invention has a metallic reinforcing braiding which provides a catheter with advantageous radiopaque properties and kink resistance.
- [0018] In accordance with a preferred embodiment of the present invention there is provided an intravascular catheter with an elongated tubular body having a proximal portion, a distal portion and a lumen extending therebetween. The tubular body has a first layer defining the lumen, the first layer made of a polymer having a coefficient of friction of less than about 0.50; a second layer disposed about the first layer, the second layer made of a polymer selected from polyetherester elastomer, polybutylene terephthalate, and combinations thereof; and a reinforcing means. The first layer may be a polymer selected from polytetrafluoroethylene, polyvinylidene fluoride, and polyamide, and may be a polymer having a kinetic coefficient of friction (steel on polymer) less than about 0.35, and preferably less than about 0.10. The first layer may consist essentially of polytetrafluoroethylene. The second layer may have a durometer of from about 30D - 90D, and may be from about 38D - 74D. In one embodiment, the second layer will preferably be about 30D at the distal end of the bodystock and about 90D at the proximal end of the bodystock. The second layer may be polyetherester blended with polybutylene terephthalate such as about 10 - 94 weight percent polybutylene terephthalate. The second layer may have about 8 - 12 weight percent polyetherester and about 88 - 92 weight percent polybutylene terephthalate. The reinforcing means may be totally embedded between the first layer and the second layer, or substantially embedded in the second layer. The reinforcing means may be a braided metal mesh of filaments extending from the proximal portion of the tubular body toward the distal portion of the tubular body by a predetermined distance. The reinforcing means may extend to the distal portion of the catheter. The braided metal mesh may be metal filaments braided in a 1 over 1 pattern or 2 over 2 configuration, and may be made of filaments formed of a metal selected from stainless steel and ELGILOY nickel-cobalt alloy. The reinforcing means may be a polymer forming a mesh, a tube, or a fabric, and the polymer may be carbon fibers or polyaramide. The intravascular catheter may have an annular soft-tip member bonded to the distal end of the tubular body member, and the soft-tip member may be polyetherester elastomer having a durometer less than about 50D. The intravascular catheter may have an outer diameter in the range of from about 2 French to 24 French, preferably from about 1,3 to about 4 mm (about 4 French to about 12 French).
- [0019] In another embodiment of the present invention, the present invention relates to a guide catheter having an elongate tubular body with a proximal portion, a distal portion and a lumen extending therebetween. The tubular body has an outside diameter of from about 1,3 to about 4 mm (about 4 French to about 12 French) and has a first layer forming the lumen and made of polytetrafluoroethylene; a braided metal mesh of filaments at least partially surrounding the inner layer and a second layer at least partially covering the reinforcing means, the second layer made of a blend of polyetherester elastomer and polybutylene terephthalate. The second layer may have a durometer of from about 38D - 74D, and may be made of about 10 - 94 weight percent polybutylene terephthalate. In one embodiment, the second layer will preferably be about 30D at the distal end of the bodystock and about 90D at the proximal end of the bodystock. The second layer will preferably be made of about 8 - 12 weight percent polyetherester and about 88 - 92 weight percent polybutyleneterephthalate. The braided metal mesh may be made of metal filaments braided in a 1 over 1 pattern or 2 over 2 configuration. The intravascular catheter may further include an annular soft-tip member bonded to the distal end of the tubular body member, and the soft-tip member may comprise polyetherester elastomer having a durometer less than about 50D.

[0020] In another embodiment of the present invention, the present invention relates to an intravascular catheter having an elongate tubular body having a proximal portion, a distal portion and a lumen extending therebetween. The tubular body may be made of: (a) polymeric material containing substantially no radiopaque filler; and (b) metallic reinforcing braiding configured with sufficient effective thickness to provide the elongate tubular body with substantial radiopacity. The polymeric material may be a polymer selected from polyetherester elastomer, polybutylene tere-phthalate, and combinations thereof. The metallic reinforcing braiding may be configured in a one-over-one paired wire construction.

[0021] In yet another embodiment of the present invention, an intravascular catheter has an elongate tubular body with a proximal portion, a distal portion and a lumen extending therebetween, and the tubular body is made of: (a) polymeric material containing substantially no radiopaque filler and (b) metallic reinforcing braiding, wherein the combination of polymeric material comprising substantially no radiopaque filler and metallic braid has an amount of radiopacity which is greater than or equal to the amount of radiopacity which would result from a catheter without metallic reinforcing consisting of polymeric material loaded with 20% barium sulfate, preferably greater than about 30%, more preferably between about 30-40%.

[0022] The foregoing features, objects and advantages of the invention will become apparent to those skilled in the art from the following detailed description of certain preferred embodiments especially when considered in conjunction with the accompanying drawings in which like numerals in the several views refer to corresponding parts. These figures are provided to illustrate, and not limit, the present invention.

- 20 FIG. 1 is a plan view of one embodiment of the guiding catheter of this invention with a portion of the catheter removed to show the construction of the bodystock;
- FIG. 2 is a longitudinal sectional view of the distal portion of one embodiment of the guiding catheter of this invention prior to the attachment of the stem and tip;
- 25 FIG. 3 is a longitudinal sectional view of the stem transition sleeve and stem sleeve prior to assembly of the guiding catheter of this invention;
- FIG. 4 is a longitudinal sectional view of the distal portion of one embodiment of the guiding catheter of this invention;
- FIG. 5 is a plan view of the distal portion of the guiding catheter of this invention showing the stem transition sleeve, stem sleeve and soft tip;
- 30 FIG. 6 is a perspective view of a diagnostic catheter constructed in accordance with the present invention;
- FIG. 7 is a cross-sectional view of the catheter of FIG. 6 taken along the line 2-2;
- FIG. 8 is a cross-sectional view taken through the stem member of the catheter along the line 3-3 in FIG. 6;
- 35 FIG. 9 is a longitudinal cross-sectional view taken along the line 4-4 which passes through the joint between the tubular body stock and the stem member;
- FIG. 10 is a longitudinal cross-sectional view taken through the distal end portion of the catheter along the line 5-5 in FIG. 6;
- FIG. 11 is a plan view of an additional embodiment of the present invention;
- 40 FIGS. 12 and 13 show alternative embodiments of metallic reinforcing braiding in accordance with the present invention;
- FIG. 14 shows alternative angles of braiding according to the present invention; and
- FIG. 15 shows a cross-section of a catheter in accordance with the present invention.

#### Description of the Preferred Embodiments

[0023] One embodiment of the invention is a guiding catheter 10 which has a tubular bodystock 20 and a soft tip 30 attached to the distal end of bodystock 20. Guiding catheter 10 can have any desired inner diameter and outer diameter. Typical dimensions are an inner diameter of between about 0.050 inches to about 0.130 inches (0.127 cm to 0.330 cm) and an outer diameter of about 0.070 inches to about 0.150 inches (0.178 cm to 0.381 cm). A conventional polycarbonate hub 40 is attached to the proximal end of bodystock 20. In addition, an extruded strain relief tube 50 is connected to hub 40 and the proximal portion of bodystock 20. Strain relief tube 50 preferably may have a tapered design as shown in FIG. 1. However, a constant outside diameter construction could also be used.

[0024] Bodystock 20 is formed from an inner liner 21, an intermediate wire mesh braid 22 and an outer jacket 23. Inner liner 21 is formed from a polymer having a coefficient of friction of less than about 0.50, preferably polytetrafluoroethylene. Suitable polytetrafluoroethylene can be purchased on the open market. The polytetrafluoroethylene preferably has a thickness of between about 0.0010 inches (0.0025 cm) and about 0.0050 inches (0.0127 cm).

[0025] Inner liner 21 when formed from a polymer having a coefficient of friction of less than 0.50 provides a lubricious surface facing the lumen of guiding catheter 10. This facilitates the passage of other medical devices therethrough.

[0026] Metallic reinforcing braid 22 is formed from, e.g., stainless steel wires disposed over inner liner 21. Although stainless steel wire is preferred, other suitable materials such as ELGILOY nickel-cobalt alloy could also be used. The

stainless steel wire may have a circular cross-section with a diameter of between about 0.0010 inches (0.0025 cm) and about 0.0050 inches (0.0076 cm), preferably about 0.003 inches (0.007 cm). Alternatively, a flat wire could be used. The metallic reinforcing braid 22 is described in more detail below.

[0027] Outer jacket 23 is formed from a blend of polyetherester elastomer and polybutylene terephthalate (PBT).

5 Suitable polyetherester elastomer and polybutylene terephthalate (PBT) can be purchased on the open market. Outer jacket 23 may have a durometer of between about 38D and about 74D. In one embodiment, the second layer will preferably be about 30D at the distal end of the bodystock and about 90D at the proximal end of the bodystock. The use of a polyetherester elastomer/PBT blend provides a bodystock material that is sufficiently stiff so that guiding catheter 10 has a proximal portion with enhanced "pushability" and "torqueability".

10 [0028] Preferably, the polymeric material for outer jacket 23 and inner liner 21 will contain substantially no radiopaque fillers such as barium sulfate, bismuth subcarbonate, bismuth trioxide and bismuth oxychloride. Preferably the outer jacket 23 and/or inner liner 21 will contain less than 5 weight percent radiopaque filler, more preferably less than 1 weight percent, even more preferably less than 0.5 weight percent, and most preferably 0 weight percent. A pigment can be used to color outer jacket 23. If such a pigment is used, preferably about 0.05 to about 0.5% by weight is used.

15 Lesser or greater amounts of the pigment can be used depending on the color desired.

[0029] Soft tip 30 constitutes the most distal end of guiding catheter 10. It is formed from polyetherester elastomer. Preferably soft tip 30 has a durometer of between about 25D and about 50D. This gives soft tip 30 a softness that is sufficient to minimize the chances of damage to the inner surface of a blood vessel through which a guiding catheter 10 may pass. In addition, it is hard enough to maintain an opening therethrough to allow the passage of a guidewire, 20 balloon catheter or other interventional medical devices to pass out of the distal end of soft tip 30. Soft tip 30 can be made radiopaque by mixing, e.g., 15 - 50% by weight barium sulfate with the polyetherester elastomer. Of course greater or lesser amounts of barium sulfate or other radiopaque filler can be used. A 4% by weight loading of titanium dioxide can be used to color soft tip 30. Again greater or lesser amounts of titanium dioxide can be used. Preferably soft tip 30 has a length of between about 0.04 inches (0.10 cm) to about 0.20 (0.51 cm) inches.

25 [0030] Guiding catheter 10 may have a stem 80 located between bodystock 20 and soft tip 30. Stem 80 is composed of stem transition sleeve 51 and a stem sleeve 52. Stem transition sleeve 51 is formed from 38D to 55D polyetherester elastomer. It will preferably contain no radiopaque fillers such as barium sulfate. Organic pigment can be used. Stem sleeve 52 is formed from 38D to 55D polyetherester elastomer. It will preferably contain no radiopaque fillers such as barium sulfate. 4% by weight of titanium dioxide or 0.4% by weight of an organic pigment can be used to provide color 30 to stem sleeve 52.

[0031] Stem transition sleeve 51 has a taper along the distal portion. This taper as shown is about 20 degrees but can generally be from about 0 degrees to about 30 degrees. Stem sleeve 52 has a complementary taper along its proximal portion to provide a smooth transition between stem transition sleeve 51 and stem sleeve 52. The length of stem sleeve 52 can vary depending on the length of the distal portion of guiding catheter 10 that is desired to be flexible.

35 Stem sleeve 52 may be from about 0.45 inches (1.14 cm) to about 2.1 inches (5.33 cm) as measured from its most distal end to the most proximal end of the taper. In addition, stem 150 can have a total length of between about 0.5 inches (1.27 cm) to about 6 inches (15.24 cm).

[0032] Stem transition sleeve 51 and stem sleeve 52 fit over the distal portion of bodystock 20. This configuration provides a smooth transition in the flexibility of guiding catheter 10 from its proximal end to its distal end. This smooth 40 transition from the high hardness/stiffness of bodystock 20 to the high softness of soft tip 30 eliminates stress concentration at the stem to bodystock joint. High stress concentrations at this joint would promote kinking and failure of guiding catheter 10.

[0033] Guiding catheter 10 can be manufactured according to the following process.

45 Step A:

[0034]

1. Clean a weld mandrel with alcohol and lint free cloth.
- 50 2. Slide mandrel 90% into an etched PTFE tube. Tie a knot about 1/2 inch from the end of the PTFE tube, and slide the weld mandrel the rest of the way into the PTFE. Trim excess PTFE outside of the knot.
3. Cut braided metal stock to a desired length. Slide the braid stock into an assembly tube. Remove and dispose of the braid core rod while holding the free end of the braid assembly with other hand. This leaves the unsupported braid inside the assembly tube. Slide the end of the PTFE/mandrel assembly (knot end first) into the braid which is in the assembly tube. Remove the braid/PTFE/mandrel from the assembly tube. Snug and secure the braid down onto the PTFE by pulling it axially and twisting the free ends. Trim the twisted braid back to about 1/4 inch beyond the end of the weld mandrel on both ends.
- 55 4. Cut a desired number of outer layer tubes, such as a first, second and third outer layer tubes, to desired lengths.

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Each tube may have different durometers. Make one slit in each first and second tube axially along their length. Tube three is not slit. Slide the three tubes onto the braid/PTFE/mandrel assembly. Move the tubes together until each is butted against the adjoining tube, but not overlapped. The three tubes should be approximately centered on the braid/PTFE/mandrel assembly. Slide a piece of the assembly heat shrink completely over the tubes/braid PTFE/mandrel assembly, until it is also centered on the tubes/braid/PTFE/mandrel assembly. Using a hot air source at about 200°F to 400°F, shrink the assembly heat shrink in four places: both ends and above both tube butt joints.

5 5. Place heat shrink/tubes/braid/PTFE/mandrel assembly in pre-heated convection oven at a desired temperature for a desired time and then remove. The time shall begin when the oven temperature has recovered to within 10°F of the specified temperature. During this process and during the subsequent cooldown after removal from the oven, nothing is to touch the assembly, except at the ends (where there are no tubes).

10 6. After the part has cooled to a comfortable touch, remove the heat shrink by slitting it axially over its length. Dispose of used heat shrink. Trim the twisted braid on one end of the assembly to expose the weld mandrel. Pull the weld mandrel out of the now fused tube/braid/PTFE assembly.

15 7. Trim both ends of the catheter to the specified length using a single edge razor blade and specified trim mandrel.

### Step B:

#### [0035]

- 20 1. Set a defined time and temperature of a tip welding system.
2. Cut the tip tubes to the desired length. Place one tip tube on the tip weld mandrel, and slide it against the step. Cut tip heat shrink to a desired length, and slide it onto the catheter. Gently place the tip weld mandrel/tip tube assembly into the catheter until the end of the catheter butts against the tip tube, and then slide the heat shrink onto this assembly until it overlaps the tip tube completely.
- 25 3. Ensuring that no relative motion occurs between the pieces of the weld mandrel/tip tube/catheter/heat shrink assembly, place it in the proper location between the jaws of the tip welding fixture. Axial orientation is correct when the right end of the tip welding mandrel is approximately aligned with the right end of the jaws of the welder. Start the welding system when alignment is achieved.
4. When the welding cycle is complete and the part cool to the touch, remove the heat shrink. Push the catheter off from the mandrel by pushing against the distal end of the soft tip.
- 30 5. Visually inspect the catheter/soft tip weld area with a microscope for defects.
6. Mount a trimming pin into a small lathe. Mount a rolling tip trimming tool in a lathe tool mount. Place the end of the catheter onto the trimming pin the distance necessary to achieve the specified trim length. Turning the lathe at about 20 RPM, move the trimming tool into the part until the tip is trimmed off. Stop the lathe and remove the part and discard the trimmed piece.

### Step C:

#### [0036]

- 40 1. Clean forming wires with 70:30 isopropyl alcohol/water.
2. Mount the catheter onto the forming wires until the distal tip is properly aligned on the forming wire.
3. Arrange the catheter/forming wire assemblies onto the oven tray in such a way that the soft tips are not in contact with anything other than the wire upon which they are mounted.
- 45 4. Place the tray into the forming oven at a desired temperature for a desired time.
5. After the parts have cooled, remove the forming wires and compare the shape to the specified shape template.

### Step D:

#### [0037]

- 50 1. Slide a desired strain relief onto the proximal end of the catheter about 3 inches (7.6 cm). Apply a desired adhesive around the end of the catheter in a continuous bead, leaving the last .010 to .020 inches (0.25 to .051 cm) of catheter free of adhesive. Slide the catheter into the hub, rotate the hub about 1 turn and align the wings of the hub in approximately the same plane as the formed shape. Apply another small bead of the specified adhesive to the bodystock immediately adjacent to the hub, and slide the strain relief into the hub. Blot excess adhesive from the joint. Visually inspect the inside of the hub for excess glue.

[0038] Figures 6-12 relate to a diagnostic catheter of the present invention. Referring first to Figure 6, there is indicated generally by numeral 110 a diagnostic catheter comprising the present invention. It includes an elongated tubular body 112 having a proximal end 114, a distal end 116 and a lumen 118 extending therebetween. Affixed to the proximal end 114 of the tubular body 112 is a molded plastic hub 120 having a Luer fitting 122 at its proximal end and flared wings 124 projecting radially from the diametrically opposed sides thereof to facilitate twisting of the catheter. An elastomeric sleeve 126 surrounds the proximal end portion of the tubular body 112 and functions as a strain relief member. The sleeve 126 is preferably roughened or knurled to facilitate gripping and rotation thereof using a three-finger catheter engagement. The length of the tubular body 112 will typically be 3-1/2 to 4 feet (1.1 to 1.2 meters) in length and will have an outside diameter that is generally uniform over this length and will come in various sizes from, e.g., 1 mm to 2,7 mm (3 Fr to 8 Fr).

[0039] Referring to the cross-sectional view of Figure 7, it can be seen that the tubular body 112 is formed with an inner lubricious layer 128. With this material for the inner layer 128, the surface defining the lumen 118 is inherently lubricious. The inner layer 128 preferably has a wall thickness in the range of from 0.001 to 0.008 inches (0.0025 to 0.0203 cm) with  $0.0025 \pm 0.0005$  inches ( $0.0064 \pm 0.0127$  cm) being preferred.

[0040] As can also be seen in the cross-sectional views of Figures 7 and 9, a reinforcing means, in this case a braided sleeve of metal wires 130 is disposed about the inner layer 128. As shown in FIG. 15, the cross-sectional view of the wires will generally be elliptical where the wires are braided and the filaments extend in a helix. The metallic reinforcing means 130 is described in more detail below.

[0041] Following placement of the reinforcing means, an outer layer 132 is disposed onto the assembly. The outer layer may comprise a blend of about 90 weight percent polyetherester and about 10 weight percent polybutylene terephthalate. As can be seen from the cross-sectional views of Figures 7 and 9, the outer layer 132 may totally embed the reinforcing means 130. In certain embodiments, outer layer 132 substantially embeds reinforcing means 130, such that only minor portions of the reinforcing means 130 protrude from the outer layer 132. To provide a desired shape characteristic to the distal end portion of the diagnostic catheter, a tubular stem member 134 may be thermally bonded to the distal end portion of the braided tubular body 112. As is best seen in Figure 9, the braided tubular body has its outer layer or jacket 132 ground to a bevel as at 136. By beveling the distal end portion 116 of the tubular body 112, greater surface area is provided for effecting attachment of the stem member 134. In that the grinding operation used to create the bevel reduces the thickness of the outer jacket relative to the ends of the wires 130 comprising the braided sleeve, a band or ring 138 of a non-penetrable material may be used to surround the free ends of the braid wires. Without such a band, the heating required to effect a thermal bond between the tubular body 112 and the jacket 134 may cause the frayed ends of the braid to warp or bend to the point where they can penetrate through the inner layer 128 into the lumen 118 or through the thickness of the tubular stem 134.

[0042] The stem member 134 may comprise, without limitation, polyetherester elastomer, polybutylene terephthalate (PBT), or combinations thereof. Preferably, it will comprise a blend of about 90 weight percent polyetherester and about 10 weight percent polybutylene terephthalate. A desired pigment may be added as well. Additional materials that may be added include titanium dioxide, bismuth subcarbonate and iodine compounds.

[0043] Completing the catheter is a soft-tip member 140 which may be bonded to the distal end portion of the stem member 134. A suitable durometer for the soft-tip on the catheter is 30D - 50D. That tip may be formed by injection molding or welding the material onto the distal end of the stem member 134. Alternatively, if the catheter is not designed to include a stem member, the soft-tip 140 may be injection molded directly onto a distal end portion of the braided tubular body 112 with an impenetrable ring 138 again being used to confine the braiding wire ends as the soft tip is being formed.

[0044] Using the above techniques, it has been possible to produce a 1 mm (3 Fr) O.D. catheter having a lumen with a diameter of 0.026 Inches (0.066 cm) and which still possesses excellent torquing characteristics whereby the distal end of the catheter follows a rotation of its proximal end. Moreover, even with such a relatively large diameter lumen in comparison to its outer diameter, the catheter still has adequate column strength allowing it to be advanced through the vascular system without kinking or buckling. An 2,7 mm (8 Fr) diagnostic catheter constructed in accordance with the present invention may have a lumen as large as 0.086 inches (0.218 cm), again having the desirable properties expected by most cardiologists as far as its ability to be manipulated through the application of longitudinal and rotational forces at the proximal end portion of the catheter.

[0045] The reinforcing layer of the present invention, in certain embodiments, may be completely or partially embedded in either the first or second layers. In certain embodiments, it will be partially covered by both layers.

[0046] FIG. 11 shows the outer layer of a distal portion of an alternative embodiment of the present invention. The distal portion is made of a polyetherester/PBT blend having a hardness of 90D, and a tip made of polyetherester having a hardness of 30D. Intermediate the 90D and 30D sections is an intermediate section made of polyetherester and having a hardness of 50D. In other embodiments, a hardness gradient will be used, so that the outer layer gradually becomes softer from the proximal to the distal direction of the distal portion.

[0047] FIG. 12 shows a suitable braid pattern for the reinforcing braid. Here, a 32 strand, 1-over-1, paired construction

is utilized with stainless steel wire. The preferred wire diameter may be about .0015 to .0035 inches (.0038 to .0089 cm), preferably about .0025 to .0030 inches (.0064 to .0076 cm). Preferred braiding angles, as defined below, are between about 20 - 53 degrees, preferably about 30 - 45 degrees. The braid illustrated in FIG. 12 would be made of a plurality of paired filaments, each pair extending in helix configuration along a center line of the braid as a common axis, the braid provided by a first number of paired filaments having a common direction of winding but axially displaced relative to each other pair and crossing a second number of paired filaments also axially disposed relative each other pair but having an opposite direction of winding. The paired wires, as shown, consist of two wires which make contact with one another along substantially their entire length, preferably along their entire length. The reinforcing braid will preferably be between about 90 and about 40 picks per inch. For a 2 mm (6 Fr) device, it will preferably be about 80 picks per 2,54 cm (inch), and for devices between 2,3-3,3 mm (7-10 Fr), it will preferably be about 52 picks per 2,54 cm (inch).

[0048] FIG. 13 shows an alternative braid pattern for the reinforcing means of the present invention. Here a 16 wire, two-over-two construction is utilized with stainless steel wire. The wire diameter may be the same as shown in FIG. 12. Preferred braiding angles are about 15 - 25 degrees.

[0049] FIG. 14 shows alternative angles that can be used in the present invention, namely 60°, 45°, and 30°, with the braid angle measured from the place perpendicular to the longitudinal axis of the catheter. In general, radiopacity increases as braid angles decrease.

[0050] It has been found that radiopacity can be predicted based on the effective thickness of the metal braid content, and that preferred radiopacity properties are achieved with effective thickness of greater than about 0.002 inch (0.0051 cm), preferably between about 0.002 inch (0.0051 cm) and 0.0055 inch (0.0051 and 0.0140 cm), more preferably between 0.0029 and 0.0044 inch (0.0074 and 0.0112 cm).

[0051] The effective thickness can be calculated by dividing the total cross-sectional wire area by the catheter outer diameter. The total cross-sectional area of the wires can be determined in this embodiment where all wires have the same diameter and the filaments extend in a helix by calculating the area for a single wire and multiplying the result by the number of wires to yield a total cross-sectional wire area. Then, the total cross-sectional wire area is divided by the outer catheter diameter.

[0052] With reference to FIG. 15, wires 130 are braided at an angle of 30° and have diameters of 0.0030 inches (0.0076 cm). The cross-sectional area of each wire is shown as ellipses in FIG. 15, having a major diameter  $d_1$  of 0.00606 inches (0.0154 cm) and a minor diameter  $d_2$  of 0.003 inches (0.0076 cm). The cross-sectional area of each wire is  $\pi(\frac{1}{2}d_1)(\frac{1}{2}d_2) = 0.0000142$  inches<sup>2</sup> (0.0000916 cm<sup>2</sup>). The total wire cross-sectional area for all 32 wires is 0.0004544 inches<sup>2</sup> (0.002932 cm<sup>2</sup>). This value is divided by the 0.105 inch (0.267 cm) diameter (D) of the catheter, to yield an effective thickness of 0.0043 inch (0.0110 cm).

[0053] Polymeric materials that may be used in the present invention are disclosed in United States Patent Application entitled "Intravascular Catheter", Serial No. 08/647,606, filed concurrently herewith, and commonly assigned to the assignee of this application. Additional materials are disclosed in United States Patent No. 5,403,292.

[0054] United States Patent No. 5,403,292 relates to a diagnostic intravascular catheter having an elongated tubular body with a proximal end, a distal end and a lumen extending therebetween where the tubular body is formed with an inner layer consisting essentially of an unmodified polyamide polymer, preferably Nylon-12. The term "unmodified polyamide polymer" refers to the fact that nothing is added to the polymer matrix that tends to substantially change its physical properties, such as copolymers, polymer blends, miscible polymers in relation to polyamide-based polymer matrices or polymer performance enhancers which would substantially change the physical properties of the polymer. For instance, the fact that a colorant or a radiopaque filler material is added is not considered to be a modification. Nylon-12 is hydrophobic meaning that it does not absorb moisture and swell. Surrounding this inner layer is a reinforcing sleeve that extends from the proximal end of the tubular body toward the distal end. The sleeve may comprise braided filaments and may constrict the inner layer, creating microscopic bumps on the wall surface defining the lumen, effectively decreasing the contact area between an inserted guidewire and the wall surface. An outer layer, including a blend of a polyether block amide having a predetermined diameter hardness in the range of from about 50 Shore D to 75 Shore D and preferably a radiopaque filler material ( $BaSO_4$ ), covers the inner layer and the reinforcing sleeve and provides an outer diameter to the tubular body in the range of from 1-2,7 mm (3-8 Fr). Preferably affixed to the distal end of the tubular body member is a soft-tip member, which may be molded from a blend of resins such that the soft tip exhibits a hardness that is less than about 45 Shore D. The intravascular catheter may also incorporate a non-braided tubular stem member that is interposed between and bonded to both the tubular body and the soft-tip member. The stem member itself preferably comprises a single layer of a copolymer of polyamide and PEBA whose Shore hardness is in the range of from 25D to 72D. It may have a uniform or tapered outer diameter.

[0055] The following Table I provides a list of polymers suitable for a first layer of the present invention and provides certain properties of these polymers, as found in Polymer Structure, Properties and Applications, R.D. Deanin, Cahners Books (1972).

[0056] The following Tables II and III provide properties of certain polyetheresters suitable for a second layer of the

present invention.

[0057] The following Table IV provides certain properties of polybutylene terephthalate suitable for a second layer of the present invention.

[0058] Those skilled in the art will also appreciate that the intravascular catheter in accordance with the present invention can be manufactured to have a variety of different distal end shaped configurations to suit the desires of different cardiologists. In certain embodiments, the present invention can be used in such diverse catheter applications as neurological catheters, angioplasty catheters, stent deployment devices, and the like.

[0059] Various modifications and changes in detail may be made to the above-described embodiments and examples without departing from the scope of the invention as defined in the claims. It is therefore intended that all such matter as described in the foregoing description and shown in the attached drawings be considered as illustrative only and not limiting.

TABLE I

Polymer	Steel on Polymer		Polymer on Polymer	
	Static	Kinetic	Static	Kinetic
PTFE ("Teflon") (polytetrafluoroethylene)	0.10	0.05	0.04	0.04
PTFE-HFP copolymer (FEP "Teflon") (tetrafluoroethylene/ hexafluoropropylene)	0.25	0.18	—	—
Polyethylene (low density)	0.27	0.26	0.33	0.33
Polyethylene (high density)	0.18	0.08-0.12	0.12	0.11
Acetal resin ("Delrin")	0.14	0.13	—	—
Polyvinylidene fluoride	0.33	0.25	—	—
Polycarbonate	0.60	0.53	—	—
PET ("Mylar") (polyethylene terephthalate)	0.29	0.28	0.27*	0.20*
Nylon (polyhexamethylene adipamide)	0.37	0.34	0.42*	0.35*
PFCE ("Kef-F") (polytrifluorochloroethylene)	0.45*	0.33*	0.43*	0.32*
PVC (polyvinyl chloride)	0.45*	0.40*	0.50*	0.40*
PVDC (polyvinylidene chloride)	0.68*	0.45*	0.90*	0.52*

\* "Stick-slip" (intermittent motion).

TABLE II

Property/Test Method	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
Relative Viscosity/ DIN 50.049-3.1.B	3.45 ± 0.2	2.90 ± 0.2	3.20 ± 0.2	3.40 ± 0.2	2.90 ± 0.2
Moisture Content/ASTM D4019 (%)	<0.025	<0.025	<0.025	<0.025	<0.025
Melting Point/ASTM D2217 (°F)	383	365	395	415	430
Hardness/ASTM D2240 (Shore D)	38	45	55	63	74
Melt Flow Index/ASTM D1238 (g/10 min.)	25	40	10	7	4
Tensile Modulus/ASTM D638 (psi)	8,700	16,000	32,000	54,000	130,000
Tensile Strength/ASTM D638 (psi)	2,470	3,050	4,640	5,800	6,520
Elongation at Break/ASTM D638 ( % )	700	800	650	600	360
Flexural Modulus/ASTM D790 ( % )	7,980	15,000	29,000	48,500	117,000

TABLE III

Property/Test Method	
Melt Flow Rate, 190°C at 2.16kg/ASTM D-1238 (g/10 min.)	5.0 ± 1.5

TABLE III (continued)

Property/Test Method	
Melting Point / ASTM D-3418 (°C)	170±3
Specific Gravity	1.07 ±0.02
Hardness / ASTM D2240 (Durometer)	30
Flex Modulus / ASTM D790 at 73°F (psi)	4000
Tensile Strength at Break / ASTM D638 (psi)	3800
Elongation at Break / ASTM D638 (%)	700

TABLE IV

Property/Test Method	
Viscosity Number/ISO 1628-5 (cm <sup>3</sup> /g)	165 ± 7
Volume Melt Flow Rate/ISO 1133 (cm <sup>3</sup> /10 min.)	10 ± 3
Moisture Content/ASTM D4019 (wt. - %)	≤ 0.05
Density at 23°C/ISO 1183 (g/cm <sup>3</sup> )	1.31 ± 0.03
Melting Range/DSC (°C)	221-226
Tensile Strength at Yield/ISO 527 (N/mm <sup>2</sup> )	≥ 50
Elongation at Yield/ISO 527 (%)	≥ 3
Tensile Strength at Break/ISO 527 (N/mm <sup>2</sup> )	≥ 30
Elongation at Break/ISO 527 (%)	≥ 100
Modulus of Elasticity/ISO 527 (N/mm <sup>2</sup> )	≥ 2200

**Claims**

1. A catheter comprising an elongate tubular body having a proximal portion, a distal portion, and a lumen extending there between, the tubular body comprising:

- (a) polymeric material; and
- (b) a metallic reinforcing braid (22,130), characterized in that

the metallic reinforcing braid (22,130) comprises elongated circular cross-section filaments, the braid (22,130) having an effective thickness, calculated as total cross-sectional wire area divided by catheter outer diameter, of greater than 0.0051 cm (0.002 inches).

- 2. The catheter of claim 1 wherein the metallic reinforcing braid (22,130) has an effective thickness of between about 0.0074 cm (0.0029 inches) and about 0.0112 cm (0.0044 inches).
- 3. The catheter of claim 1, in which the elongate tubular body has a proximal portion, a distal portion and a lumen extending there between, wherein

- 5
- (a) the polymeric material comprising substantially no radiopaque filler; and
  - (b) wherein the combination of polymeric material comprising substantially no radiopaque filler and metallic braid (22,130) has an amount of radiopacity which is greater than or equal to the amount of radiopacity which would result from a catheter without metallic reinforcing consisting of polymeric material loaded with 20% barium sulfate.
- 10
- 4. The catheter of claim 3 wherein the combination of polymeric material comprising substantially no radiopaque filler and metallic braid (22,130) has an amount of radiopacity which is greater than or equal to the amount of radiopacity which would result from a catheter without metallic reinforcing consisting of polymeric material loaded with 30% barium sulfate.
- 15
- 5. The catheter of claim 4 wherein the combination of polymeric material comprising substantially no radiopaque filler and metallic braid (22,130) has an amount of radiopacity which is greater than or equal to the amount of radiopacity which would result from a catheter without metallic reinforcing consisting of polymeric material loaded with 40% barium sulfate.
- 20
- 6. The catheter of claim 1 comprising:
    - (a) a first layer (21,128) defining the lumen, the first layer (21,128) comprising polymeric material having a kinetic coefficient of friction (steel on polymer) of less than about 0.50;
    - (b) a second layer (23,132) disposed about the first layer (21,128), the second layer (23,132) comprising polymeric material selected from polyetherester elastomer, polybutylene terephthalate, and combinations thereof.
- 25
- 7. The catheter of claim 6 wherein the first layer (21,128) comprises a polymer selected from the group consisting of polytetrafluoroethylene, polyvinylidene fluoride, and polyamide.
- 30
- 8. The catheter of claim 6 wherein the first layer (21,128) comprises a polymer having a kinetic coefficient of friction (steel on polymer) less than about 0.10.
- 9. The catheter of claim 8 wherein the first layer (21,128) consists essentially of polytetrafluoroethylene.
- 35
- 10. The catheter of claim 6 wherein the second layer (23,132) has a durometer of from about 30D to 90D.
- 11. The catheter of claim 6 wherein the second layer (23,132) comprises polyetherester blended with polybutylene terephthalate.
- 40
- 12. The catheter of claim 11 wherein the second layer (23,132) comprises about 10 - 94 weight percent polybutylene terephthalate.
- 13. The catheter of claim 12 wherein the second layer (23,132) comprises about 8 -12 weight percent polyetherester and about 88 to 92 weight percent polybutylene terephthalate.
- 45
- 14. The catheter of claim 6 wherein the reinforcing braid (22,130) is totally embedded between the first layer (21,128) and the second layer (23,132).
- 15. The catheter of claim 6 wherein the reinforcing braid (22,130) is substantially embedded in the second layer (23,132).
- 50
- 16. The catheter of claim 6 wherein the reinforcing braid (22,130) is a metallic braid (22,130) of filaments and the reinforcing element (22,130) extends from the proximal portion of the tubular body toward the distal portion of the tubular body by a predetermined distance.
- 55
- 17. The catheter of claim 16 wherein the metallic braid (22,130) comprises metal filaments braided in a one-over-one pattern.
- 18. The catheter of claim 16 wherein the metallic braid (22,130) comprises metal filaments braided in a two-over-two configuration.

19. The catheter of claim 16 wherein the metallic braid (22,130) comprises filaments formed of a metal selected from stainless steel and ELGILOY nickel-cobalt alloy.
- 5      20. The catheter of claim 17 wherein the tubular body comprises a first polymeric layer (21,128) defining the lumen and a second polymeric layer (23,132) defining an outside surface of the tubular body, and the metallic reinforcing braid (22,130) is disposed between the lumen and the outside surface.
- 10     21. The catheter of claim 20 wherein the first polymeric layer (21,128) comprises polytetrafluoroethylene and the second polymeric layer (23,132) comprises a polymer selected from polyetherester elastomer, polybutylene terephthalate, and combinations thereof.
- 15     22. The catheter of claim 20 wherein the first polymeric layer (21,128) consists essentially of an unmodified polyamide polymer and the second polymeric layer (23,132) comprises a polyether block amide.
- 20     23. The catheter of claim 17 wherein the paired filaments are configured at a braid angle of between about 20 and about 53 degrees preferably between about 30 and about 45 degrees measured perpendicular to a longitudinal axis of the catheter (10,110).
24. The catheter of claim 17 wherein the filaments are configured at between 40 and about 90 picks per 2,54 cm (1 inch).
- 25     25. The catheter of claim 17 wherein the metallic reinforcing braid (22,130) comprises 16 or 32 strands.
26. The catheter of claim 17 wherein the filaments have diameters of between about 0.0038 cm (0.0015 inches) and about 0.0089 cm (0.0035 inches) and preferably between about 0.0064 cm (0.0025 inches) and about 0.0076 cm (0.0030 inches).

#### Patentansprüche

- 30     1. Katheter umfassend einen länglichen, rohrförmigen Körper mit einem proximalen Abschnitt, einem distalen Abschnitt und einem Lumen, welches sich durch diese erstreckt, wobei der rohrförmige Körper umfasst:
- 35        (a) ein polymeres Material; und  
               (b) ein metallisches Verstärkungsgeflecht (22, 130), dadurch gekennzeichnet, dass  
               das metallische Verstärkungsgeflecht (22, 130) längliche, im Querschnitt kreisförmige Filamente umfasst, wobei das Geflecht (22, 130) eine effektive Dicke größer als 0,0051 cm (0,002 Inch) hat, die als Gesamt-Querschnitts-Drahtfläche dividiert durch den Katheter-Außendurchmesser berechnet wird.
- 40     2. Katheter nach Anspruch 1, worin das metallische Verstärkungsgeflecht (22, 130) eine effektive Dicke zwischen etwa 0,0074 cm (0,0029 Inch) und etwa 0,0112 cm (0,0044 Inch) hat.
- 45     3. Katheter nach Anspruch 1, in dem der längliche rohrförmige Körper einen proximalen Abschnitt, einen distalen Abschnitt und ein Lumen hat, das sich durch diese hindurch erstreckt, worin  
               (a) das polymere Material im Wesentlichen kein strahlungsdurchlässiges Füllmittel umfasst; und  
               (b) worin die Kombination des polymeren Materials, das im Wesentlichen kein strahlungsdurchlässiges Füllmittel enthält, und des Metallgewebes (22, 130) einen Betrag an Strahlenundurchlässigkeit hat, der größer oder gleich im Betrag der Strahlungsdurchlässigkeit ist, welcher sich bei einem Katheter ohne metallische Verstärkung ergeben würde, der aus einem polymeren Material besteht, der mit 20% Bariumsulfat beschickt ist.
- 50     4. Katheter nach Anspruch 3, worin die Kombination aus dem polymeren Material, das im Wesentlichen kein strahlungsdurchlässiges Füllmittel umfasst, und des Metallgewebes (22, 130) einen Betrag an Strahlungsdurchlässigkeit hat, der größer oder gleich dem Betrag der Strahlungsdurchlässigkeit ist, welcher sich bei einem Katheter ohne Metallverstärkung ergeben würde, der aus einem polymeren Material besteht, das mit 30% Bariumsulfat beschickt ist.

5. Katheter nach Anspruch 4, worin die Kombination des polymeren Materials, das im Wesentlichen kein strahlungs- undurchlässiges Füllmittel enthält, und des Metallgewebes (22, 130) einen Betrag an Strahlungsdurchlässigkeit hat, der größer oder gleich dem Betrag der Strahlungsdurchlässigkeit ist, die sich bei einem Katheter ohne Metallverstärkung ergeben würde, der aus einem polymeren Material besteht, welches mit 40% Bariumsulfat beschickt ist.
6. Katheter nach Anspruch 1 umfassend:
  - 10 (a) eine erste Schicht (21, 128), die ein Lumen definiert, wobei die erste Schicht (21, 128) ein polymeres Material umfasst, das einen genetischen Reibungskoeffizienten (Stahl auf Polymerem) von weniger als 0,50 hat;
  - (b) eine zweite Schicht (23, 132), die um die erste Schicht (21, 128) angeordnet ist, wobei die zweite Schicht (23, 132) ein polymeres Material aufweist, welches aus Polyätherester-Elastomeren, Polybutylenterephthalat und Kombinationen davon ausgewählt wurde.
- 15 7. Katheter nach Anspruch 6, worin die erste Schicht (21, 128) ein Polymeres umfasst, welches aus der Gruppe bestehend aus Polytetrafluoräthylen, Polyvenylenfluorid und Polyamid ausgewählt wurde.
- 20 8. Katheter nach Anspruch 6, worin die erste Schicht (21, 128) ein polymeres umfasst, welches einen genetischen Reibungskoeffizienten (Stahl auf Polymerem) von weniger als etwa 0,10 hat.
9. Katheter nach Anspruch 8, worin die erste Schicht (21, 128) im Wesentlichen aus Polytetrafluoräthylen besteht.
- 25 10. Katheter nach Anspruch 6, worin die zweite Schicht (23, 132) einen Durometerwert von etwa 30 D bis 90 D hat.
11. Katheter nach Anspruch 6, worin die zweite Schicht (23, 132) einen Polyätherester umfasst, der mit Polybutylenterephthalat durchmischt ist.
- 30 12. Katheter nach Anspruch 11, worin die zweite Schicht (23, 132) etwa 10-94 Gewichtsprozent Polybutylenterephthalat umfasst.
13. Katheter nach Anspruch 12, worin die zweite Schicht (23, 132) etwa 8-12 Gewichtsprozent Polyätherester und etwa 88-92 Gewichtsprozent Polybutylenterephthalat umfasst.
- 35 14. Katheter nach Anspruch 6, worin das Verstärkungsgeflecht (22, 130) vollständig zwischen der ersten Schicht (21, 128) und der zweiten Schicht (23, 132) eingebettet ist.
15. Katheter nach Anspruch 6, worin das Verstärkungsgeflecht (22, 130) im Wesentlichen in der zweiten Schicht (23, 132) eingebettet ist.
- 40 16. Katheter nach Anspruch 6, worin das Verstärkungsgeflecht (22, 130) ein metallisches Geflecht (22, 130) aus Filamenten ist, und worin das Verstärkungselement (22, 130) sich von dem proximalen Abschnitt des rohrförmigen Körpers zu dem distalen Abschnitt des rohrförmigen Körpers um einen vorgegebene Distanz erstreckt.
- 45 17. Katheter nach Anspruch 16, worin das metallische Geflecht (22, 130) metallische Filamente aufweist, die in einem eins-über-eins-Muster geflochten sind.
18. Katheter nach Anspruch 16, worin die metallische Verstärkung (22, 130) metallische Filamente umfasst, die in einer zwei-über-zwei-Konfiguration geflochten sind.
- 50 19. Katheter nach Anspruch 16, worin die metallische Verstärkung (22, 130) Filamente umfasst, die aus einem Metall gebildet sind, welches aus rostfreiem Stahl und einer ELGILOY-Nickel-Kobalt-Legierung ausgewählt wurde.
20. Katheter nach Anspruch 17, worin der rohrförmige Körper eine erste polymere Schicht (21, 128), die ein Lumen definiert, und eine zweite polymere Schicht (23, 132) aufweist, die eine Außenfläche des rohrförmigen Körpers definiert, und worin das metallische Verstärkungsgeflecht (22, 130) zwischen dem Lumen und der Außenfläche angeordnet ist.

21. Katheter nach Anspruch 20, worin die erste polymere Schicht (21, 128) Polytetrafluorethylen und die zweite polymere Schicht (23, 132) ein Polymeres umfasst, welches aus einem Polyetherester-Elastomeren, Polybutylen-terephthalat und Kombinationen davon ausgewählt wurde.
- 5    22. Katheter nach Anspruch 20, worin die erste polymere Schicht (21, 128) im Wesentlichen ein unmodifiziertes Polyamid-Polymeres und die zweite polymere Schicht (23, 132) ein Polymer-Block-Amid aufweist.
- 10    23. Katheter nach Anspruch 17, worin die geflochtenen Filamente mit einem Flechtwinkel von zwischen etwa 20° und etwa 53°, vorzugsweise zwischen etwa 30° und etwa 45°, gemessen senkrecht zu der Längsachse des Katheters (10,110) konfiguriert sind.
- 15    24. Katheter nach Anspruch 17, worin die Filamente bei zwischen 40 und etwa 90 Maschen pro 2,54 cm (1 Inch) konfiguriert sind.
- 20    25. Katheter nach Anspruch 17, worin das metallische Verstärkungsgeflecht (22, 130) 16 oder 32 Litzen umfasst.
- 25    26. Katheter nach Anspruch 17, worin die Filamente Durchmesser zwischen etwa 0,0038 cm (0,0015 Inch) und etwa 0,0089 (0,0035 Inch) und vorzugsweise zwischen etwa 0,0064 cm (0,0025 Inch) und etwa 0,0076 cm (0,0030 Inch) haben.

#### Revendications

1. Un cathéter comprenant un corps tubulaire allongé ayant une partie proximale, une partie distale et une lumière s'étendant entre lesdites parties ; le corps tubulaire comprenant :
  - (a) de la matière polymère ; et
  - (b) un entrelacs métallique de renforcement (22, 130) **caractérisé en ce que**

30    l'entrelacs métallique de renforcement (22, 130) comporte des filaments circulaires en section transversale ; l'entrelacs (22, 130) ayant une épaisseur effective (calculée en tant que zone de file totale en section transversale, laquelle zone étant divisée par le diamètre extérieure de cathéter) de plus de 0,0051 cm (0,002 pouces).
2. Le cathéter selon la revendication 1, **caractérisé en ce que** l'entrelacs (22, 130) a une épaisseur effective comprise entre environ 0,0074 cm (0,0029 pouces) et environ 0,0112 cm (0,0044 pouces).
3. Le cathéter selon la revendication 1, dans lequel le corps tubulaire allongé a une partie proximale, une partie distale et une lumière s'étendant entre lesdites parties, où
  - (a) la matière polymère ne comporte essentiellement pas de matière de remplissage opaque aux rayons X ; et
  - (b) où la combinaison de la matière polymère ne comprenant essentiellement pas de matière de remplissage opaque aux rayons X et d'entrelacs (22, 130) métallique a une opacité aux rayons X supérieure ou égale à l'opacité aux rayons X qui résulterait d'un cathéter sans renforcement métallique composé d'une matière polymère chargée avec 20% de sulfure de barium.
4. Le cathéter selon la revendication 3, dans lequel la combinaison de la matière polymère comprenant essentiellement aucune matière de remplissage opaque aux rayons X et d'entrelacs (22, 130) métallique a une opacité aux rayons X supérieure ou égale à l'opacité aux rayons X qui résulterait d'un cathéter sans renforcement métallique composé d'une matière polymère chargée avec 30% de sulfure de barium.
5. Le cathéter selon la revendication 4, dans lequel la combinaison de la matière polymère ne comprenant essentiellement pas de matière de remplissage opaque aux rayons X et d'entrelacs (22, 130) métallique a une opacité aux rayons X supérieure ou égale à l'opacité aux rayons X qui résulterait d'un cathéter sans renforcement métallique composé d'une matière polymère chargée avec 40% de sulfure de barium .
6. Le cathéter selon la revendication 1, comprenant :
  - (a) une première couche (21, 128) délimitant la lumière, la première couche (21, 128) comprenant une matière

polymère ayant un coefficient de friction cinématique (de l'acier sur du polymère) inférieur à environ 0,50 ;  
 (b) une deuxième couche (23, 132) disposée autour de la première couche (21, 128), la deuxième couche (23, 132) comprenant de la matière polymère sélectionnée à partir des polyéthers d'esters élastomère, polybutylène téréphthalate, et une combinaison de ces matières.

- 5        7. Le cathéter selon la revendication 6, dans lequel la première couche (21, 128) comprend un polymère sélectionné à partir du groupe consistant de polytétrafluoroéthylène, Fluorure de polyvinylidène et polyamide.
- 10      8. Le cathéter selon la revendication 6, dans lequel la première couche (21, 128) comprend un polymère ayant un coefficient de friction cinématique (de l'acier sur du polymère) inférieur à environ 0,10.
- 15      9. Le cathéter selon la revendication 8, dans lequel la première couche (21, 128) est constituée essentiellement de polytétrafluoroéthylène .
- 20      10. Le cathéter selon la revendication 6, dans lequel la deuxième couche (23, 132) présente une dureté d'environ 30D à 90D.
- 25      11. Le cathéter selon la revendication 6, dans lequel la deuxième couche (23, 132) comprend de polyéther d'esters mélangé avec de polybutylène téréphthalate .
- 30      12. Le cathéter selon la revendication 11, dans lequel la deuxième couche (23, 132) comprend environ 10 à 94 % en poids de polybutylène téréphthalate.
- 35      13. Le cathéter selon la revendication 12, dans lequel la deuxième couche (23, 132) comprend environ 8 à 12 % en poids de polyéther d'esters et environ 88 à 92 % en poids de polybutylène téréphthalate.
- 40      14. Le cathéter selon la revendication 6, dans lequel l'entrelacs de renforcement (22, 130) est entièrement scellé entre la première couche (21, 128) et la deuxième couche (23, 132).
- 45      15. Le cathéter selon la revendication 6, dans lequel l'entrelacs de renforcement (22, 130) est essentiellement scellé dans la deuxième couche (23, 132).
- 50      16. Le cathéter selon la revendication 11, dans lequel l'entrelacs de renforcement (22, 130) est un entrelacs métallique (22, 130) en filaments et l'élément de renforcement (22, 130) s'étend sur une distance prédéterminée à partir de la partie proximale du corps tubulaire vers la partie distale du corps tubulaire .
- 55      17. Le cathéter selon la revendication 16, dans lequel l'entrelacs métallique (22, 130) comprend des filaments métalliques tressés dans un motif un-sur-un.
- 60      18. Le cathéter selon la revendication 16, dans lequel l'entrelacs métallique (22, 130) comprend des filaments métalliques tressés dans une configuration deux-sur-un.
- 65      19. Le cathéter selon la revendication 16, dans lequel l'entrelacs métallique (22, 130) comprend des filaments en un métal sélectionné à partir d'acier inoxydable et l'alliage nickel-cobalt ELGILOY.
- 70      20. Le cathéter selon la revendication 17 dans lequel le corps tubulaire comprend une première couche polymère (21, 128) délimitant la lumière et une deuxième couche polymère (23, 132) définissant une surface extérieure du corps tubulaire, et ledit entrelacs métallique de renforcement (22, 132) étant disposé entre la lumière et la surface extérieure.
- 75      21. Le cathéter selon la revendication 20 dans lequel la première couche polymère (21, 128) comprend du polytétrafluoroéthylène et la deuxième couche polymère (23, 132) comprend un polymère sélectionné à partir des polyéthers d'esters élastomère, polybutylène téréphthalate, et une combinaison de ces matières.
- 80      22. Le cathéter selon la revendication 20, dans lequel la première couche polymère (21, 128) consiste essentiellement en un polymère polyamide non modifié et la deuxième couche polymère (23, 132) comprend un polyéther bloc amide.

23. Le cathéter selon la revendication 17 dans lequel les filaments en paire sont configurés selon un angle d'entrelacement d'environ 20 à environ 53 degrés, de préférence, entre environ 30 à environ 45 degrés, mesurés de façon perpendiculaire par rapport à l'axe longitudinal du cathéter (10, 110).
- 5      24. Le cathéter selon la revendication 17, dans lequel les filaments sont configurés entre environ 40 et environ 90 fils par 2,54 cm (1 pouce).
- 10     25. Le cathéter selon la revendication 17 dans lequel l'entrelacs métallique de renforcement (22, 130) comprend 16 ou 32 fils.
- 15     26. Le cathéter selon la revendication 17 dans lequel les filaments ont des diamètres d'environ 0,0038 cm ( 0,0015 pouces) et d'environ 0,0089 cm (0,0035 pouces) et de préférence entre environ 0,0064 cm (0,0025 pouces) et environ 0,0076 cm (0,0030 pouces) .

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FIG. 1

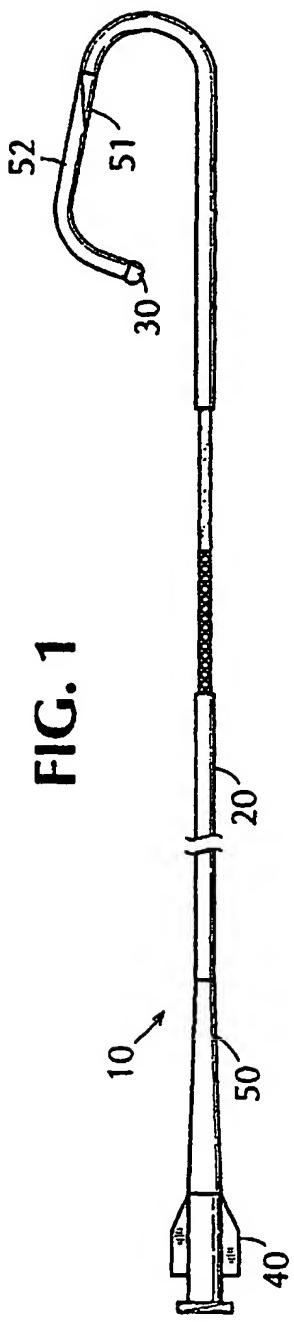


FIG. 5

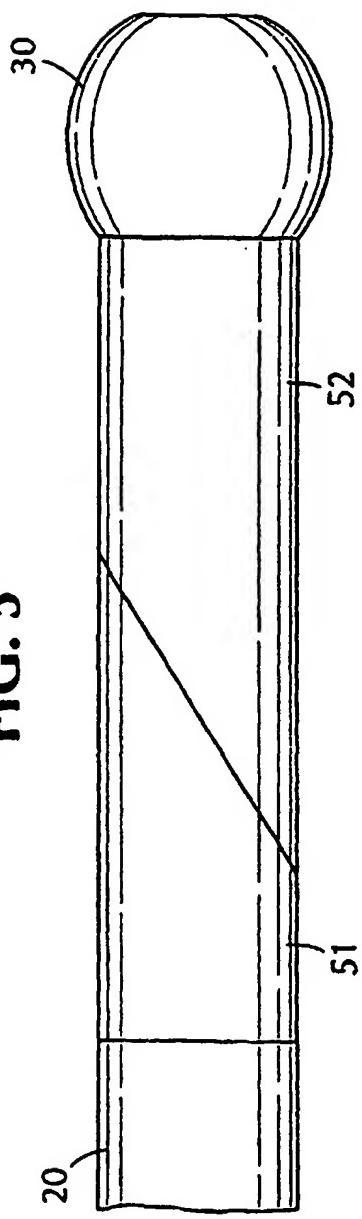


FIG. 2

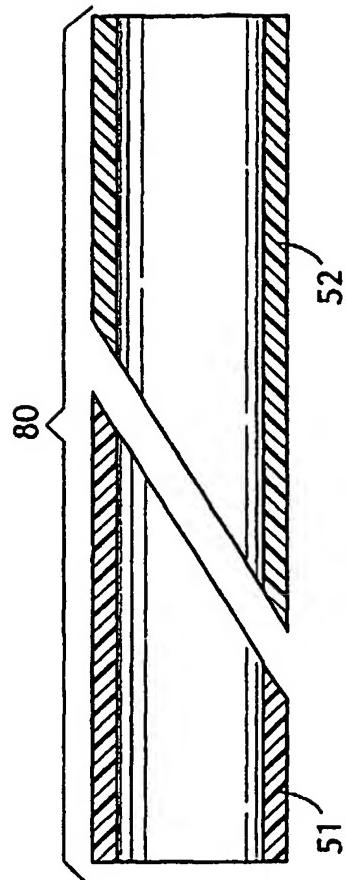
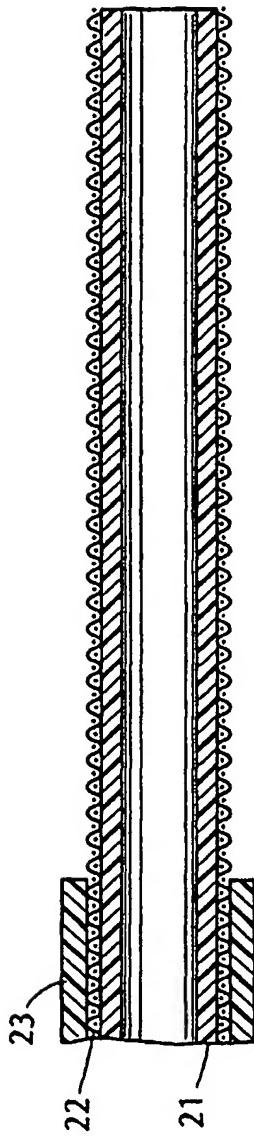


FIG. 3

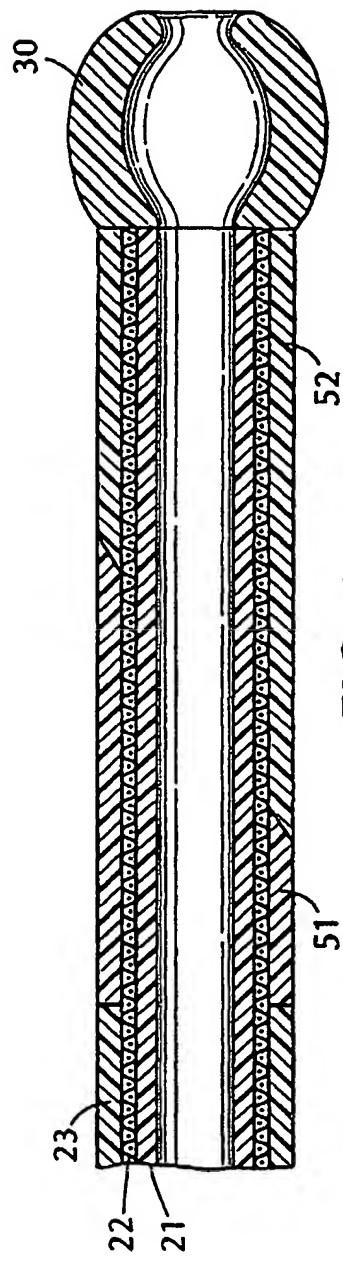
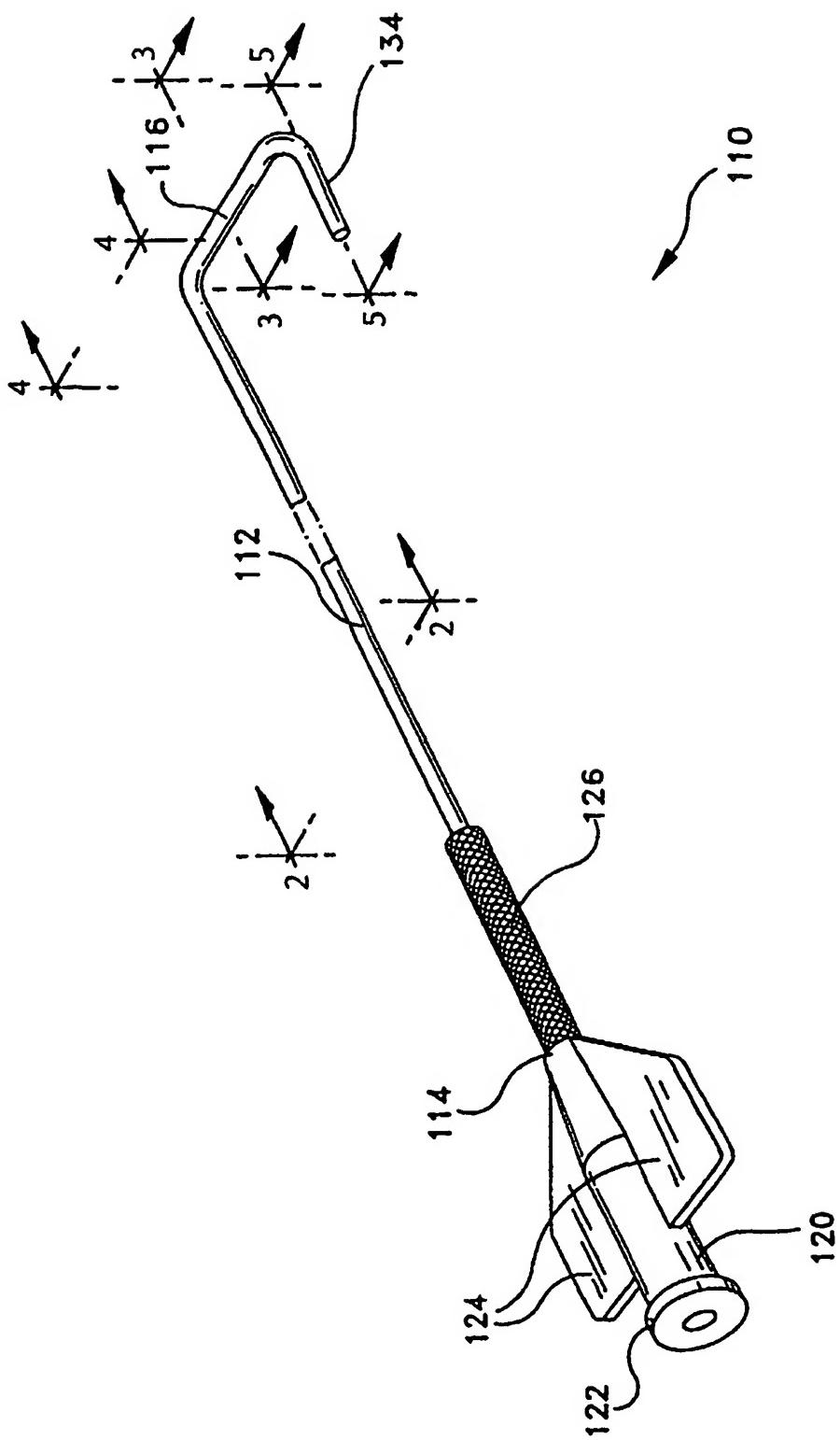
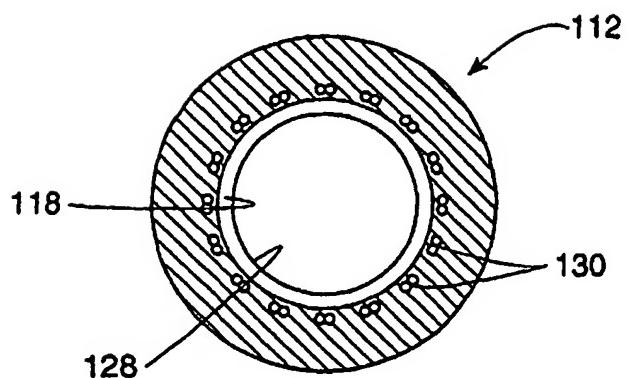


FIG. 4

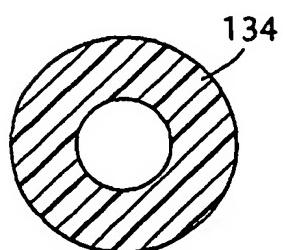
FIG. 6



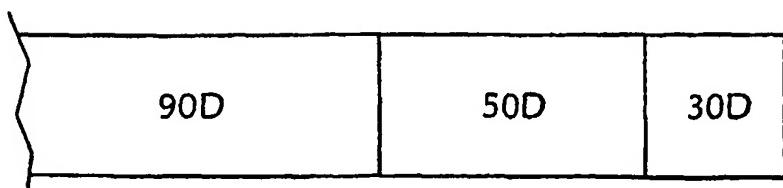
**FIG. 7**

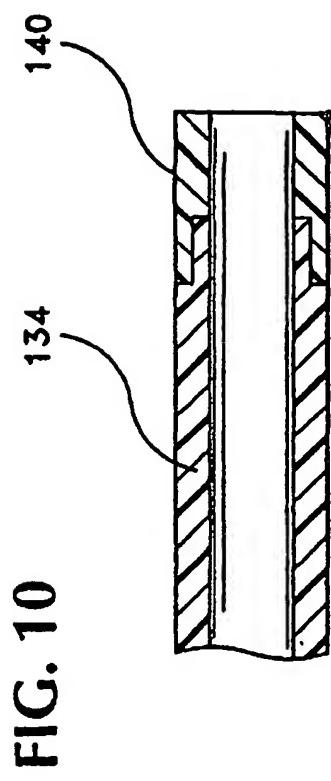
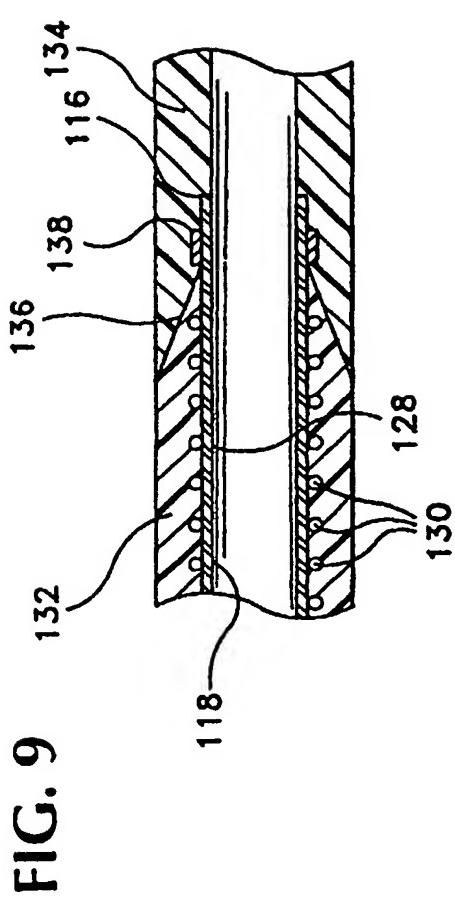


**FIG. 8**

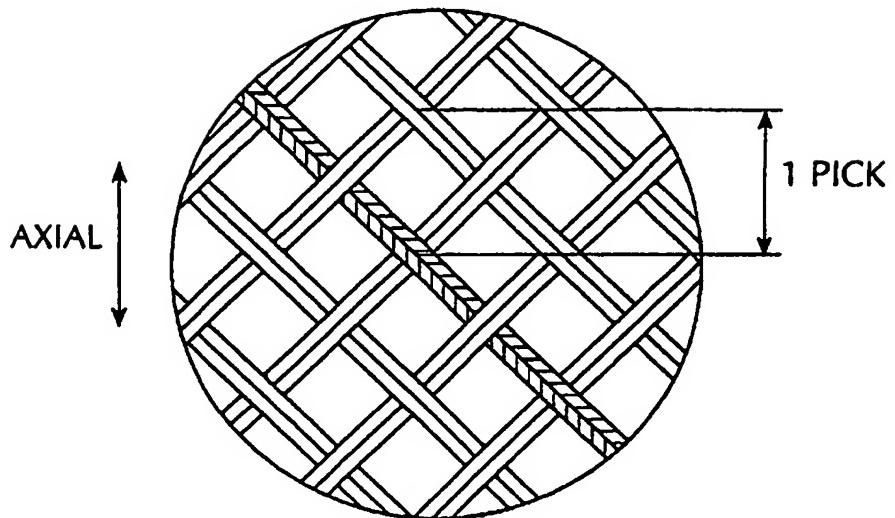


**FIG. 11**





**FIG. 12**



**FIG. 13**

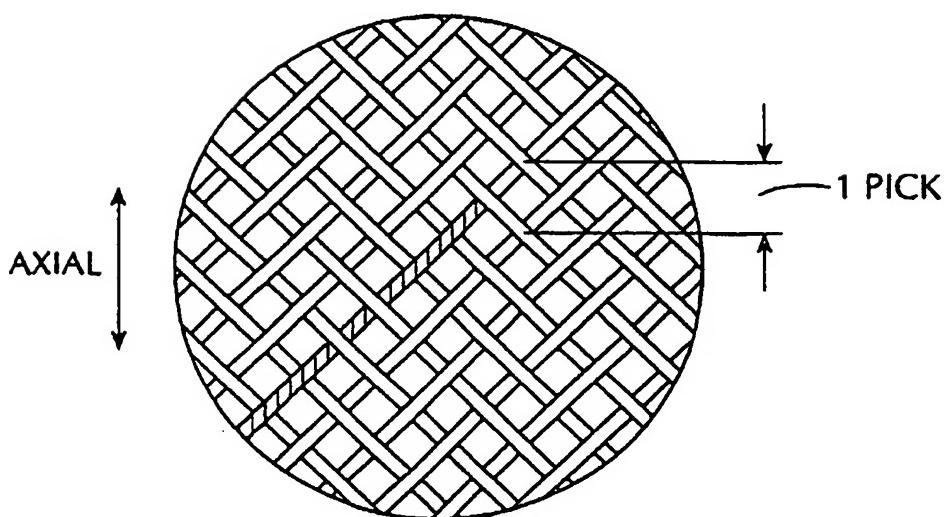
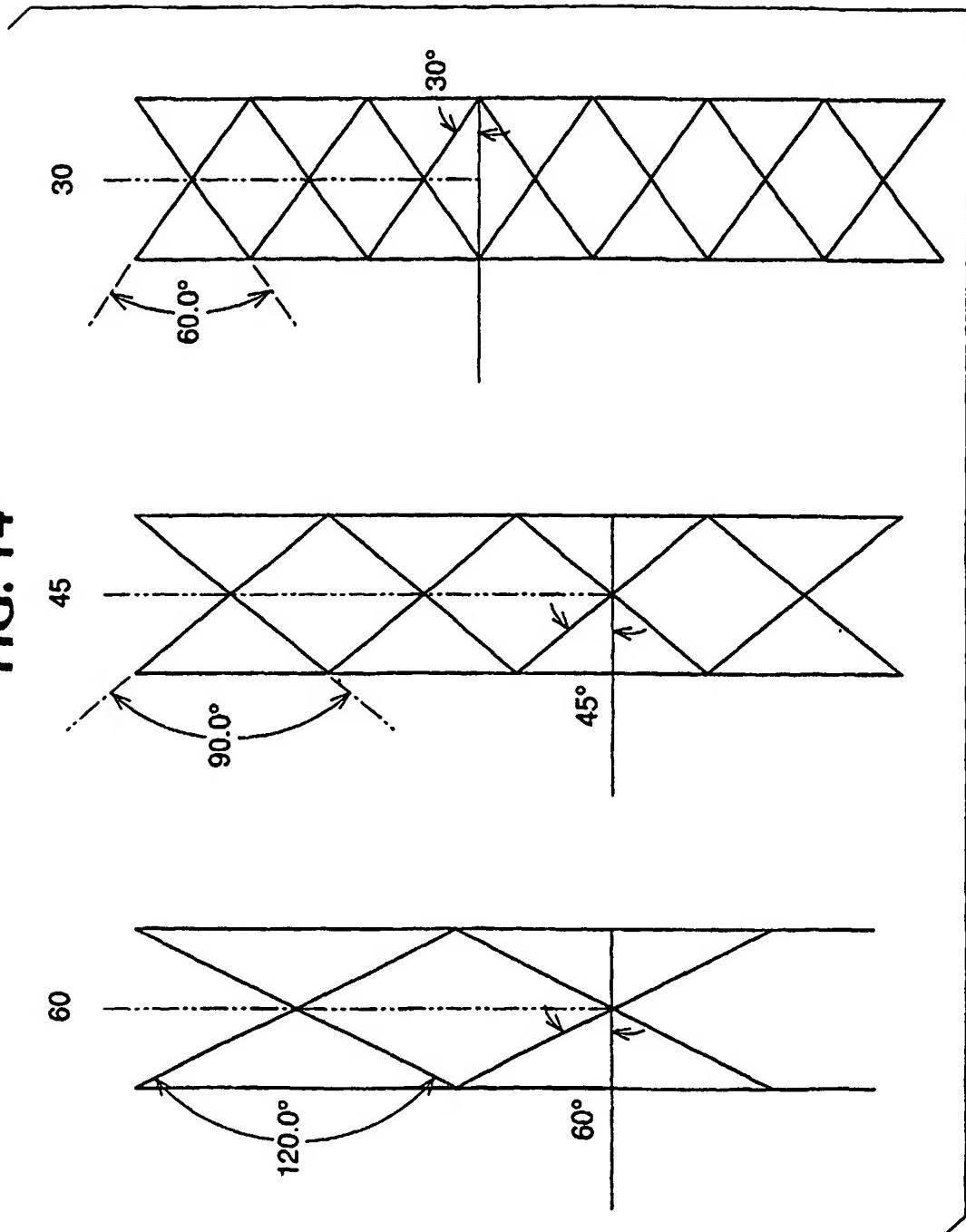


FIG. 14



**FIG. 15**

